BANGALORE ELECTRICITY SUPPLY COMPANY LIMITED

TECHNICAL SPECIFICATION FOR 45kN COMPOSITE INSULATORS
FOR USE IN 11 kV SYSTEM

1.0. SCOPE

This specification covers design, manufacture, testing and supply of composite insulators for use in the 11 kV overhead transmission lines and substations. The composite insulators shall be of the following type:

i) Long rod insulators for conductors in tension application at angle/cut points. The insulators shall be of **tongue and clevis type**.

2.0 APPLICABLE STANDARDS

2.1 Standards

Following Indian/ International Standards, which shall mean latest revision, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification, shall be referred while accessing conformity of insulators with these specifications.

2.1.1 In the event of supply of insulators conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent or better to those specified. In case of award, salient features of comparison between the standards proposed by the Bidder and those specified in this document will be provided by the Supplier to establish equivalence.

Sl No	IS Standard	Title	International Standard
1		Definition. test methods and acceptance criteria for composite insulators for A.C. overhead lines above 1000 V	IEC: 61109
2	IS: 731	Porcelain insulators for overhead Power lines with a nominal voltage greater than 1000 V	IEC: 60383
3	IS: 2071	Methods of High Voltage Testing	IEC: 60060-1
4	IS: 2486	Specification for Insulator fittings for Overhead Power Lines with a nominal Voltage greater than 1000V General Requirements and Tests Dimensional Requirements Locking Devices.	IEC: 60120 IEC: 60372
5		Thermal Mechanical Performance test and mechanical performance test on string insulator units.	IEC: 60575
6	IS: 13134	Guide for the selection *of* insulators in respect *of* polluted Conditions	IEC: 60815
7		Characteristics *of* string insulator units *of* the long rod type	IEC: 60433
8		Hydrophobicity Classification Guide	STRI Guide 1.92/1

9		Radio interference characteristics *of* overhead power lines and high-voltage equipment.	CISPR:18-2 Part-2
10	IS: 8263	Methods *of* RI *Test of* HV insulators	IEC: 60437
11		Standard for Insulators Composite-Distribution Dead-end Type.	ANSI C29. 13-2000
12	IS: 4759	Hot dip zinc coatings on structural steel & other allied products.	ISO:1459 ISO:1461
13	IS:2629	Recommended Practice for Hot Dip Galvanization for iron and steel	ISO:1461(E)
14	IS: 6745	Determination of Weight of Zinc Coating on Zinc coated iron and steel articles	ISO:1460
15	IS:3203	Methods of testing of local thickness of electroplated coatings	ISO:2178
16	IS:2633	Testing of Uniformity of Coating of zinc coated articles	
17		Standard specification for glassfiber strands	ASTM D 578-05
18		Standard test method for compositional analysis by Thermogravimetry.	ASTM E 1131-03
19	IS: 4699	Specification for refined secondary Zinc	

3.0 Technical Description of Composite Insulators

3.1 Service condition

The polymer insulators to be supplied shall be suitable for satisfactory continuous operation under conditions as specified below:

Maximum ambient temperature : 50°C
Minimum ambient temperature : 5°C (minus 5°C)
Relative humidity : 0 to 100%

3.2. Composite insulators long rod type for tension locations

3.2.1 The insulators shall be suitable for 3-Ph, 50 Hz, effectively earthed 11 kV O/H distribution system in a heavily polluted atmosphere. Long rod insulators shall be of **tongue and clevis type.**

3.2.2 Insulators shall have sheds with good self-cleaning properties. Insulator shed profile, spacing, projection etc. and selection in respect of polluted conditions shall be generally in accordance with the recommendation of IEC -60815/15: 3134.

3.2.3 The size of Composite insulator, minimum creepage distance and mechanical strength along with hardware fittings shall be as follows:

Sl No	Type of Composite insulator	Nominal System Voltage kV(rms)	Highest System Voltage kV(rms)	Visible discharge test voltahe kV(rms)	Wet power frequency withstand voltage kV(rms)	Impulse withstand voltage kVP	Minimum creapage distance in mm	Min. failing load kN	Pin ball shank diameter mm
1	Long Rod Insulator	11	12	9	40	110	320	45	17

3.3. Dimensional Tolerance of Composite Insulators

The tolerances of all dimensions e.g. diameter, length and creepage distance shall be allowed as follows in line with IEC61109:

+/-(0.04d+1.5)mm when d<=300mm.

+/-(0.025d+6)mm when d>300mm.

Where, d being the dimensions in millimeters for diameter, length or creepage distance as the case may be.

However, no negative tolerance shall be applicable to creepage distance.

3.4. Interchangeability

The composite insulators including the end fitting connection shall be of standard design suitable for use with the hardware fittings of any make conforming to relevant IEC/IS standards.

3.5. Corona and **RI** Performance

All surfaces shall be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The insulator and metal parts shall be so designed and manufactured that it shall avoid local corona formation and not generate any radio interference beyond specified limit under the operating conditions.

3.6. Maintenance

The composite insulator offered shall be suitable for use of hot line maintenance technique so that usual hot line operation can be carried out with ease, speed and safety.

4.0. BASIC FEATURES

4.1. Design and construction

The composite insulator shall have a core, housing & weathershed of insulating material and steel/aluminum hardware components for attaching it to the support/conductor.

4.1.1 Core

It shall be a glass-fiber reinforced epoxy resin rod of high strength (FRP rod). Glass fibers and resin shall be optimized in the FRP rod.Glass fibers shall be Boron free electrically corrosion resistant (ECR) glass fiber or Boron free E-glass and shall exhibit both high electrical integrity and high resistance to acid corrosion. The matrix of the FRP rod shall be Hydrolysis resistant. The FRP rod shall be manufactured through Pultrusion process. The FRP rod shall be void free. All rods must pass electric leakage current test of 170V/mm. The leakage current shall not exceed 0.05mA.

4.1.2 Housing (Sheath)

The FRP rod shall be covered by a seamless sheath of Silicone Elastometric compound or Silicone Alloy compound/EVA (ethylene vinyl Acetate) of thickness of 3mm minimum.

It should protect the FRP rod against environmental influences, external pollution and humidity. It shall be extruded or directly molded on the core and shall have chemical bonding with the FRP rod. The strength of the bond shall be greater than the tearing strength of the polymer. Sheath material in the bulk as well as in the sealing/bonding a rea shall be free from voids.

4.1.3. Weathersheds

The composite polymer weathersheds made of silicone elastometic compound or silicon alloy or EVA shall be firmly bonded to the sheath, vulcanized to the sheath or molded as part of the sheath and shall be free from imperfections. The weathersheds should be EVA or have silicon content of minimum 30% by weight. The strength of the weathershed to sheath interface shall be greater than the tearing strength of the polymer. The interface, if any, between sheds and sheath (housing) shall be free from voids.
Housing and weathershed material shall have tensile strength of 10 MPa with 300% elongation minimum and tear strength of 20N/mm.

4.1.4 End Fittings

End fittings transmit the mechanical load to the core. They shall be made of spheroidal graphite cast iron, malleable cast iron or forged steel or aluminum alloy. They shall be connected to the rod by means of a controlled compression technique. The gap between fitting and sheath shall be sealed by a flexible silicone electrometric compound or silicone alloy compound sealant. System of attachment of end fitting to the rod shall provide superior sealing performance between housing, i.e. seamless sheath and metal connection. The sealing must be moisture proof.
The dimensions of end fittings of Insulators shall be in accordance with the standard dimensions stated in IS: 2486 / IEC: 60120.
The 11kV, 45kN polymer dead end insulator shall be supplied with G.I bolts & nuts of Size M16”X65” and split pin(Locking pin) as per drawing enclosed.

5.0. Workmanship

5.1 All the materials shall be of latest design and conform to the best engineering practices adopted in the high voltage field. Bidders shall offer only such insulators as are guaranteed by them to be satisfactory and suitable for continued good service in power transmission lines.

5.2 The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners.

5.3 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration

5.4 The core shall be sound and free of cracks and voids that may adversely affect the insulators.

5.5 Weathersheds shall be uniform in quality. They shall be clean, sound, smooth and shall be free from defects and excessive flashing at parting lines.

5.6 End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively sealed to prevent moisture ingress; effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with out projecting points or irregularities, which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

5.7 All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 610 gm/sq.m. or 87micrometer thickness and shall be in accordance with the requirement of IS: 4759. The zinc used for galvanizing shall be of purity 99.5% as per IS: 4699. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least four successive dips each lasting for one (1) minute duration under the standard pierce test. The galvanizing shall be carried out only after any machining.

6.0 Equipment Marking

Each insulator unit shall be legibly and indelibly marked with the following details as per IEC - 611 09:

(a) Month & Year of manufacture.
(b) Min. failing load guaranteed mechanical strength in kilo Newton followed by the word 'kN' to facilitate easy identification.
(c) Manufacturer's name/Trade mark.
(d) Voltage & Type.
(e) P.O. No and Date

Following code shall be used as identification mark:

For Silicone Rubber 45 KN long rod unit : Blue.
For EVA 45 KN long rod unit : Red.

7.0. Drawings

The Insulator shall be as per the Drawing Enclosed..

8.0. Tests and Standards

Insulators offered shall be manufactured with the same configuration & raw materials *as* used in the insulators for which design & type test reports are submitted. The manufacturer shall submit a certificate for the same**.** The design & type test reports submitted shall not be more than **Five years old.**

8.1 Type Tests

The following type tests shall be conducted on a suitable number of individual insulator units, components, materials or complete strings:

8.1.1 The bidder shall submit type test reports as per IEC61109 along with the bid. Additional type tests as required above shall be carried out by the manufacturer, after award of contract for which no additional charges shall be payable. In case, the tests have already been carried out, within a year of award of contract, the manufacturer shall submit reports for the same.

SLNo	Description of type test	Test procedure/standard	
1	Dry lightning impulse withstand voltage test	As per IEC 61109	
2	Wet power frequency test	As per IEC 611 09	
3	Mechanical load-time test	As per lEC 611 09	
4	Radio interference test	As per lEC 61109	
5	Recovery of Hydrophobicity test in case of Silicone/Silicone alloy.	Annexure- A	This test may be repeated every 3yrs by the manufacturer
6	Chemical composition test for silicon content test in case of Silicone/Silicone alloy.	Annexure-A	Or any other test method acceptable to the owner.
7	Brittle fracture resistance test	Annexure-A	

8.1.2 **U.V Resistance as per ASTMG 53: 5000 Hrs**- UV Light for 8 Hours and condensation for 4 hours in a continuous cycle. Elongation to be limited to 20% (% Elongation to break before and after the test)

8.1.3 **Salt Fog test:** On insulators for 1000 hours as per IEC.

8.1.4 It shall be the option of the owner to accept the insulators based on type test reports submitted by the manufacturer. The owner shall be free to repeat the type test & may witness the same.

8.1.5 All the type test given in Clause No. 8.2 in addition to routine & acceptance test shall be carried out on insulator along with hardware fittings wherever required.

8.2 Acceptance (sample) Tests For Composite Insulators

(a)	Verification of dimensions	Clause 7.2 IEC: 61109,
(b)	Verification of the locking system: (if applicable)	Clause 7.3 IEC : 61109,
(c)	Galvanizing test	IS:2633/15: 6745
(d)	Verification of the specified mechanical load	Clause 7.4IEC: 61109,

8.3 Routine Tests

Sl No	Description	Standard
1	Identification of marking	As per IEC: 61109
2	Visual Inspection	As per IEC:61109
3	Mechanical Routine test	As per IEC:61106

8.4 Tests during manufacture:

Following tests shall also be carried out on all components as applicable

a)	Chemical analysis of zinc used for galvanizing.
b)	Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings.
c)	Chemical analysis, hardness tests and magnetic particle inspection for forgings.

8.5 Tests on the material used in manufacture of the insulator:

The bidder shall furnish following test reports conducted on the raw materials (i.e., silicon rubber or EVA) for confirming following properties along with their bid.

Sl. No	Property	Standard
1	Tensile Strength (MPa)	ISO37/ASTM D 638
2	Elongation (%)	ISO37/ASTM D 638
3	Tear Strength (N/mm)	ASTM D624B
4	TERT (4.5KV 360min)	ASTM D2303/IEC507
5	Volume Resistivity (Ohm –cm)	ASTM D257/IEC93
6	Dielectric constant	IEC 250/ ASTM D150
7	Dielectric Strength (kv/mm)	ASTM D149/IEC93
8	Density	ISO 1183A
9	Hardness (shore A)	ISO868
10	Accelerated aging	ISO188/ ASTM G53
11	Flammability test	UL-94 V0/IEC60707
12	Arc Resistance	IEC61621

8.6 The following characteristics shall be met by FRP rods used in manufacture of the insulator:

1. . Tensile strength: 760 N/mm² Min
2. Glass content (%) : 75% min
3. Tg by DSC – 110 Deg C min
4. Dye penetration – No dye rise on 10 sample of 10 mm thick> 15 mins
5. Water diffusion & Voltage tests – 100 hours – 12kv for 1 min, no puncture or flashover on the FRP & current shall not exceed 1 mA
6. Hardness> 51 Barcol No
7. ECR glass – Boron/alkali content not more than 0.8%.

8.7 Additional Tests

8.7.1 The Owner reserves the right at his own expenses, for carrying out any other test(s) of reasonable nature carried out at Supplier's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material comply with the Specifications.

8.7.2 The Owner also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test center. In case of evidence of non compliance, it shall be binding on the part of the Supplier to prove the compliance of the items to the technical specifications by repeat tests or correction of deficiencies or replacement of defective items, all without any extra cost to the Owner.

8.8 Co-ordination for Testing

8.8.1. The bidder shall intimate the Owner about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance of the scheduled date of testing during which the Owner will arrange to depute his representative to be present *at* the time of carrying out the tests.

8.9 Quality assurance plan

8.9.1 The successful bidder shall submit following information to the owner:

8.9.1.1 Test certificates of the raw materials and bought out accessories

8.9.1.2 Statement giving list of important raw materials, their grades along with names of sub-suppliers for raw materials, list of standards according to which the raw materials are tested. List of tests normally carried out on raw materials in presence of bidder's representative

8.9.1.3 List of manufacturing facilities available.

8.9.1.4 Level of automation achieved and lists of areas where manual processing exists.

8.9.1.5 List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.

8.9.1.6 List of testing equipments available with the bidder for final testing of

equipment along with valid calibration reports.

8.9.1.7 The manufacturer shall submit Manufacturing Quality Plan (MQP) for Approval and the\ same shall be followed during manufacture and testing.

8.9.2 The successful bidder shall submit the routine test certificates of bought out raw materials/accessories and central excise passes for raw material at the time of inspection.

9.0 RETEST AND REJECTION:

9.1 Sample Procedure for testing of insulators shall be as per clause 7.1 to 7.6 of IEC 61109 for Acceptance & Routine Tests. For the sampling tests, two samples are used, E1and E2. The sizes of these samples are indicated in the table below.

Lot Size(N)	Sample size	
	E1	E2
N<300	Subject to agreement	
300<N<2000	4	3
2000<N<5000	8	4
5000<N<10000	12	6

If more than 10000 insulators are concerned, they shall be divided into an optimum number of lots
comprising between 2000 and 10000 insulators. The results of the tests shall be evaluated separately
for each lot. The insulators shall be selected by the purchaser's representative from the lot at random.

The samples shall be subjected to the applicable sampling tests.

The sampling tests are:

Verification of dimensions - (E1 + E2)
Verification of the locking system - (E2)
Verification of tightness of the interface between end fittings & Insulator housing - (E2)
Verification of the specified mechanical load SML - (E1)
Galvanizing test - (E2)

In the event of a failure of the sample to satisfy a test, the retesting procedure shall be as follows :
If only one insulator or metal part fails to comply with the sampling tests, a new sample equal to twice
the quantity originally submitted to the tests shall be subjected to retesting. The retesting shall
comprise the test in which failure occurs.

If two or more insulator or metal parts fail to comply with any of the sampling tests or if any failure occurs during the retesting, the complete lot is considered as not complying with this standard and shall be withdrawn by the manufacturer.

Provided the cause of the failure can be clearly identified, the manufacturer may sort the lot to eliminate all the insulators with these defects. The sorted lot then be resubmitted for testing. The number then selected shall be three times the first chosen quantity for tests. If any insulators fail during this retesting, the complete lot is considered as not complying with this standard and shall be withdrawn by the manufacturer.

9.2 Verification of dimensions (E1 + E2)

The dimensions given in the drawings shall be verified. The tolerances given in the drawing are valid.

If no tolerances are given in the drawings the values mentioned in this specification shall hold good.

9.3 Verification of the locking system (E2)

This test applies only to the insulators equipped with socket coupling as specified by IEC 120 and is performed according to IEC 383.

9.4 Verification of tightness of the interface between end fittings & Insulator housing (E2)

One insulator selected randomly from the sample E2, shall be subjected to crack indication by dye penetration, in accordance with ISO 3452,on the housing in the zone embracing the complete length of the interface between the housing and metal fitting and including an additional area, sufficiently extended beyond the end of the metal part. The indication shall be performed in the following way.

- the surface shall be properly pre-cleaned with the cleaner ;
- the penetrant, which shall act during 20 minutes, shall be applied on the cleaned surface;
- within 5 minutes after the application of the penetrant, the insulator shall be subjected, at the ambient
temperature, to a tensile load of 70 % of the SML, applied between the metal fittings; the tensile load
shall be increased rapidly but smoothly from zero up to 70 % of the SML, and then maintained at this
value for 1 minute;
- the surface shall be cleaned with the excess penetrant removed, and dried;
- the developer shall be applied if necessary;
- the surface shall be inspected.

Some housing materials may be penetrated by the penetrant. In such cases evidence shall be provided to validate the interpretation of the results. After the 1 min. test at 70 % of the SML, if any cracks occur, the housing and, if necessary, the metal fittings and the core shall be cut, perpendicularly to the crack in the middle of the widest of the indicated cracks, into two halves. The surface of the two halves shall then be investigated for the depth of the cracks.

9.5 Verification of the specified mechanical load SML

The insulators of the sample E1 shall be subjected at ambient temperature to a tensile load, applied between the couplings. The tensile load shall be increased rapidly but smoothly from zero to approximately 75 % of the SML, and then be gradually increased to the SML in a time between 30 sec. to 90 sec. If 100 % of the SML is reached in less than 90 s, the load (100 % of the SML) shall be maintained for the remainder of the 90 s. (This test is considered to be equivalent to a 1 min withstand test at the SML). The insulators have passed the test at 13.4 & 13.5 above if:

- No failure (breakage or complete pull out of the core, or fracture of the metal fitting) occurs either during the 1 min. 70 % withstand test (a) or during the 1 min.100 % withstand test (b).
- No cracks are indicated after the dye penetration method described in 13.4 above.
- The investigation of the halves described in 13.4 above shows clearly that the cracks do not reach the core.

9.6 Galvanizing test

This test shall be performed according to IS: 2633/IS: 6745 on galvanized parts.

10.0 Packing

10.1 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

10.2 Suitable cushioning, protective padding or Dunn age or spacers shall be provided to prevent damage or deformation during transit and handling.

10.3 All packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty or illegible markings. Each wooden case/crate/corrugated box shall have all the markings stenciled on it in indelible ink.

10.4 The bidders shall provide instructions regarding handling and storage precautions to be taken at site.

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Annexure-A

Tests on Insulator units

1. RIV Test (Dry)

The insulator string along with complete hardware fittings shall have a radio interference voltage level below 100 micro volts at one MHz when subjected to 50 Hz AC voltage of 10 kV & 30 kV for 11 kV insulators under dry condition. The test procedure shall be in accordance with 15:8263 IEC: 437/CISPR 18-2.

2. Brittle Fracture Resistance Test

Brittle fracture test shall be carried out on naked rod along with end fittings by applying "l n HN03 acid" (63 gm conc. HN03 added to 937 gm water) to the rod. The rod should be held at 80% of SML for the duration of the test. The rod should not fail within the 96-hour test duration. Test arrangement should ensure continuous wetting of the rod with Nitric acid.

3. Recovery of Hydrophobicity & Corona test in case of Silicone/Silicone alloy.

The test shall be carried out on 4mm thick samples of 5cm x 7cm.

i) The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the Hydrophobicity classification in line with STRJ guide for Hydrophobicity classification (Extract enclosed at Annexure - D). Dry the sample surface.

ii) The sample shall be subjected to mechanical stress by bending the sample over a ground electrode. Corona is continuously generated by applying 12 kV to a needle like electrode placed 1 mm above the sample surface. The test shall be done for 100 hrs.

iii) Immediately after the corona treatment, spray the surface with water and record the HC classification. Dry the surface and repeat the corona treatment as at clause 2 above. Note HC classification. Repeat the cycle for 1000 hrs. or until an HC of 6 or 7 is obtained. Dry the sample surface.

iv) Allow the sample to recover and repeat hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 - HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

4. Chemical composition test for Silicon content test in case of Silicone/Silicone alloy.

The content of silicon in the composite polymer shall be evaluated by EDX (Energy Dispersion X-ray) Analysis or Thermo-gravimetric analysis. The test may be carried out at CPRI or any other NABL accredited laboratory.